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Abstract

SOLID STATE NUCLEAR SAFETY SYSTEM

L. Conti and M. Conti
Divisione Tecnologica, Comitato Nazionale per l'Energia Nucleare (CNEN), Casaccia, Roma, Italia

Within the framework of its nuclear reactor development programme CNEN is carrying out a research and development scheme on nuclear reactor control equipment, known as the SCIN Programme. Under this project the Servomechanism Laboratory has developed a fairly complete set of solid state nuclear instrumentation devices.

In a general safety system we can identify:

1. alarm situation detectors (safety amplifiers, radioactivity monitors, pressure and temperature trips, etc.);
2. a logical network which works out the various alarm signals (as for instance two of three circuits, interlock circuits, etc.);
3. the magnet switch power amplifier, which supplies the direct current needed for energizing the scram (magnets or clutches) or set-back mechanism.

In our system all the alarm signals are under the form of voltage; in other words, under normal conditions the voltage is + 5V, while under alarm conditions the voltage is zero.

In this way, any possible disconnection in the alarm channels would produce a safe action. All 5V signals are electronically generated by trip detectors.

1. In the sector of alarm situation detectors we have worked out an electrometer amplifier (10^{-10} + 3.10^{-4}A f.s.) and a shut-down amplifier (10^{-6} + 10^{-4} A continuously adjustable) which employ a new continuous check method.

In both devices a 15 000 Hz check signal is superimposed to the high voltage for the compensated ionization chambers. This signal spreads through the cables and chamber capacitance, up to the d.c. feedback stabilized amplifier, at the output of which there is connected a pass-band amplifier which further intensifies the check signal. Finally, this signal is rectified into a 5 V d.c. voltage.

Thus, a failure in the whole channel (H.V. power supply cable connection, d.c. amplifier) prevents the signal from travelling further and the voltage falls from 5 to zero.

2. The logical network developed by CNEN receives the various alarm signals and provokes the actuating and warning signals, all of which are under the form of 5V-0V. The most attractive features of this unit are its fail-safe characteristic and the possibility of synthetizing any logical function, starting from the fundamental AND, OR and NOT building blocks. The fail-safe feature is obtained through a pulse modulation system.

   A fourth logical block, the RAD, is a completely fail-safe pulse-d.c. converter, required for generating the actuating or warning signals and, normally, low power d.c. signals.

3. In order to feed the actuator electromechanism, we have built two types of completely fail-safe pulse-d.c. power amplifiers. Both are basically pulse-driven d.c. - d.c. converters.

   This configuration is suitable for avoiding any unsafe failure that may occur when using solid state d.c. switching devices.

   The first amplifier can supply up to 100 W and its final stage is transistorized. The second one can supply up to 5 kW, at an efficiency of about 90% and uses silicon-controlled rectifiers.

   In the logical and power units some degree of redundancy can be employed, in order to improve the efficiency of the whole system. This same method has been used in the ROSPO organic critical facility, which achieved criticality on June 10, 1963.